US009466903B2

(12) **United States Patent**
Kajiura et al.

(10) **Patent No.: US 9,466,903 B2**
(45) **Date of Patent: *Oct. 11, 2016**

(54) **HIGH SPEED FLEXIBLE PRINTED CIRCUIT CONNECTOR**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/840,545**

(22) Filed: **Aug. 31, 2015**

(65) **Prior Publication Data**

US 2015/0372406 A1 Dec. 24, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/880,836, filed as application No. PCT/IB2011/002853 on Oct. 14, 2011, now Pat. No. 9,153,888.

(51) **Int. Cl.**

H01R 13/62	(2006.01)
H01R 12/77	(2011.01)
H01R 12/88	(2011.01)
H01R 13/6471	(2011.01)
H01R 12/72	(2011.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H01R 12/774*** (2013.01); ***H01R 12/72*** (2013.01); ***H01R 12/79*** (2013.01); ***H01R 12/88*** (2013.01); ***H01R 13/6471*** (2013.01); ***H01R 13/6477*** (2013.01); *H01R 13/6597* (2013.01)

(58) **Field of Classification Search**

CPC H01R 12/88; H01R 12/79; H01R 12/07; H01R 13/24; H01R 23/6842; H01R 13/6594; H01R 13/6597; H01R 13/6461; H01R 13/652; H01R 12/727; H01R 12/75

USPC 439/329, 493, 495, 497, 260, 607.32

See application file for complete search history.

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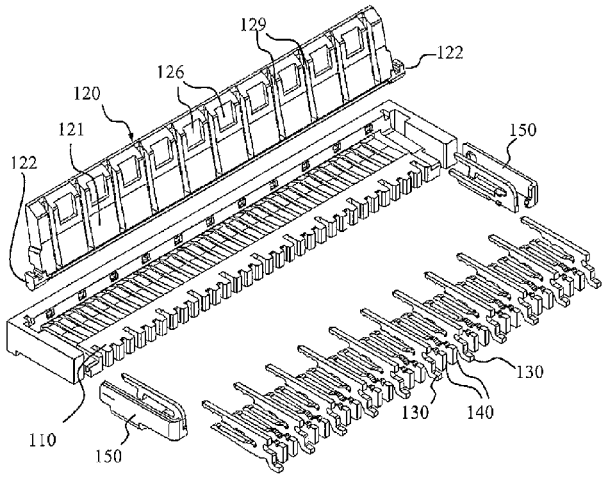
(57) **ABSTRACT**

A high speed flexible printed circuit (FPC) connector includes a housing with ground and signal contact terminal pairs arranged in the housing in a staggered manner along a lateral direction. The housing has a cavity for receiving an FPC board therein. Each ground contact terminal has an upper arm positioned adjacent to a top wall of the cavity and a lower arm positioned adjacent to a bottom wall of the cavity. Each signal contact terminal has only a lower arm positioned adjacent to the bottom wall of the cavity. Signal contact terminals with the only lower arm provide the connector with better signal integrity. An actuator is coupled to the housing for fixing the FPC board in the cavity to establish electrical connections. The actuator has recesses corresponding to the positions of the signal pairs to provide a dielectric constant different from that of the other parts of the actuator.

16 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

H01R 12/79	(2011.01)
H01R 13/6477	(2011.01)
H01R 13/6597	(2011.01)

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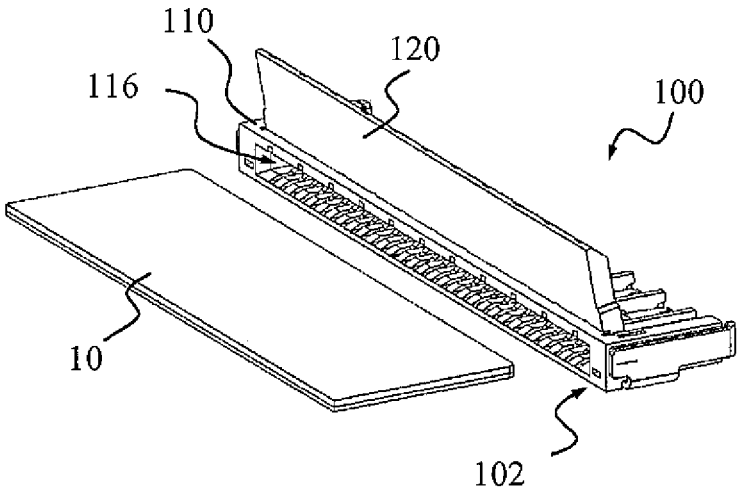
110
120
116
100
10
102

FIG. 1

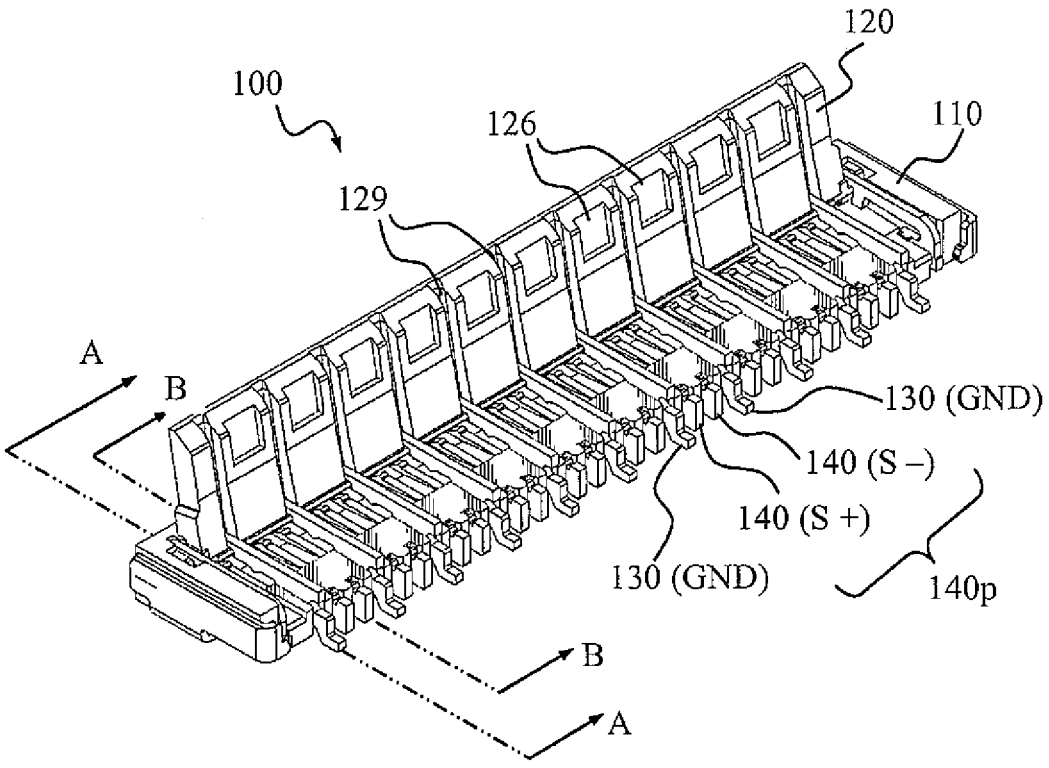
120
100
126
110
129
A
B
130 (GND)
140 (S –)
140 (S +)
130 (GND)
140p
B
A

FIG. 2

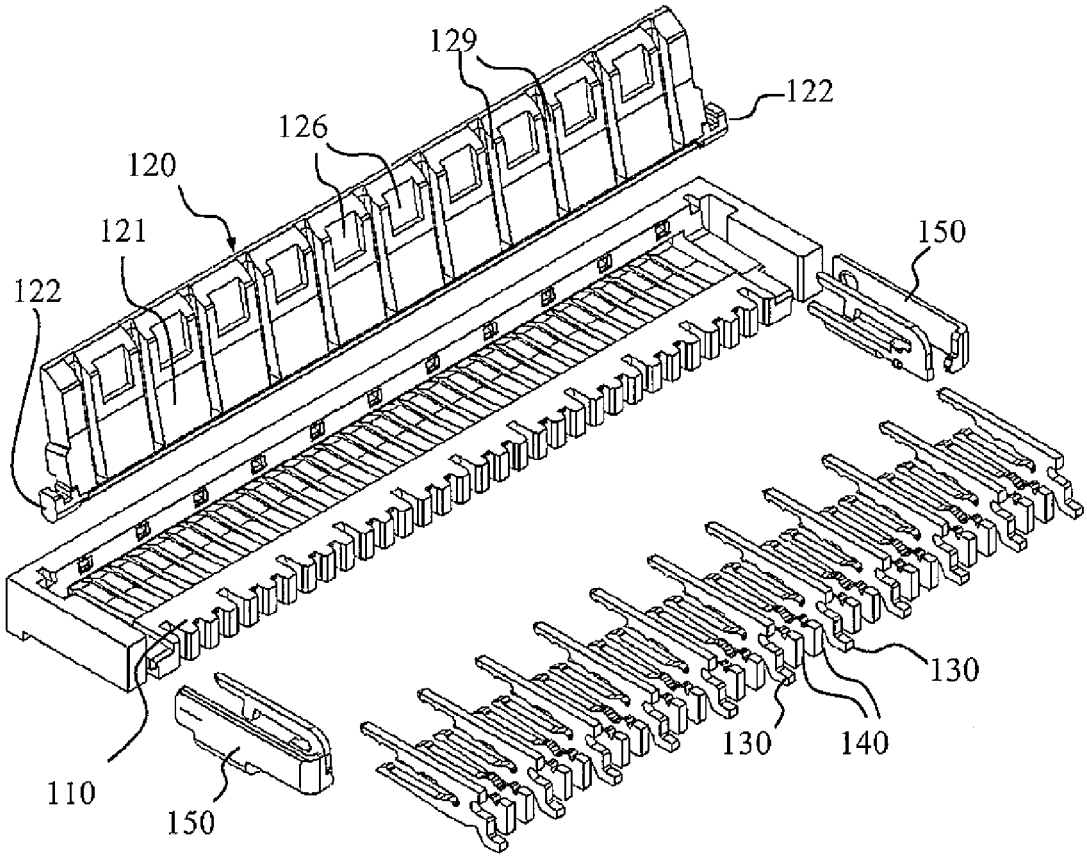

FIG. 3

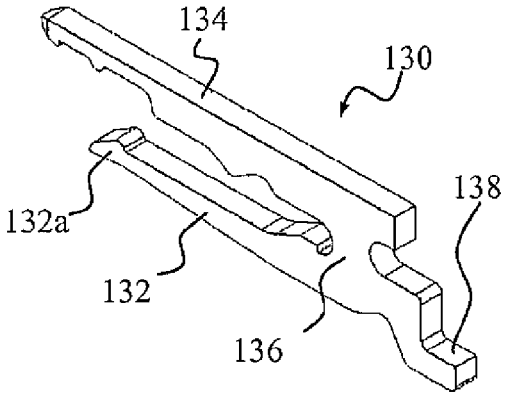

FIG. 4

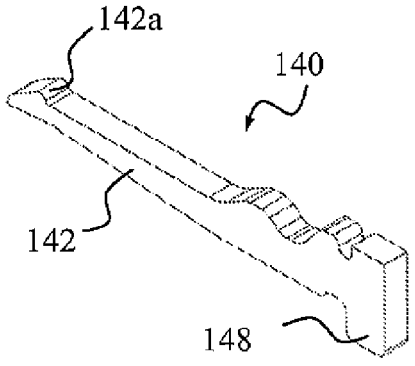

FIG. 5

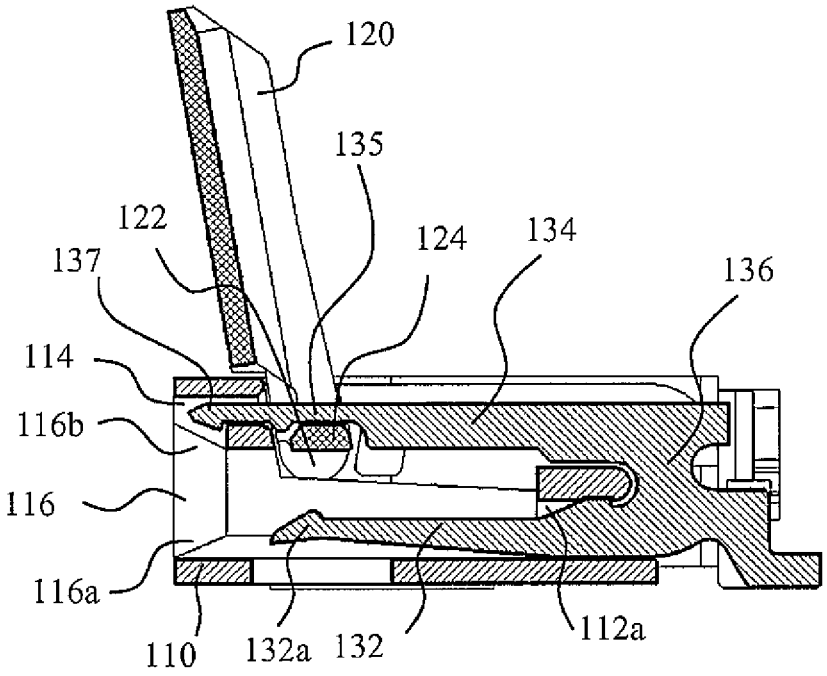
120
135
122
124
134
137
136
114
116b
116
116a
110
132a
132
112a

FIG. 6

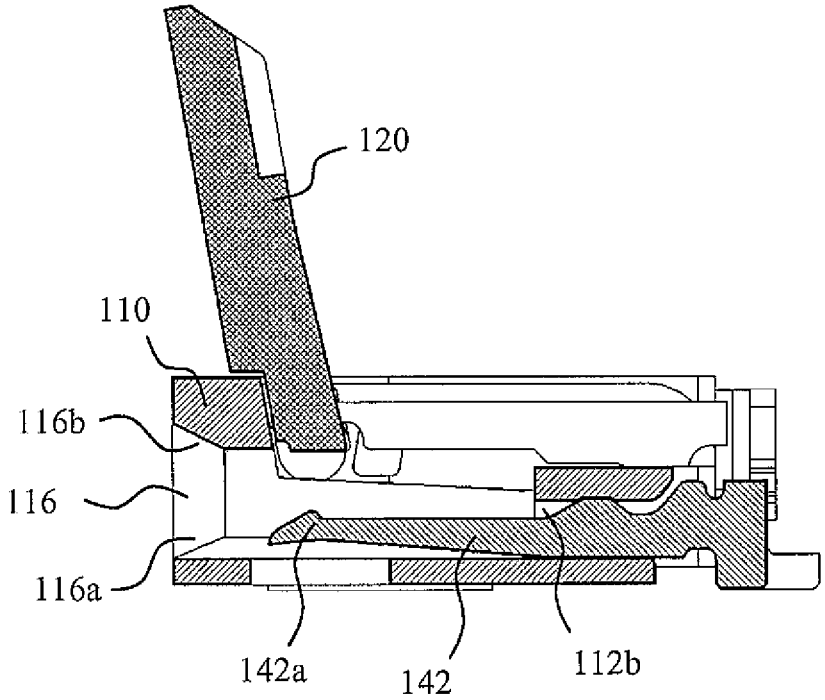
120
110
116b
116
116a
142a
142
112b

FIG. 7

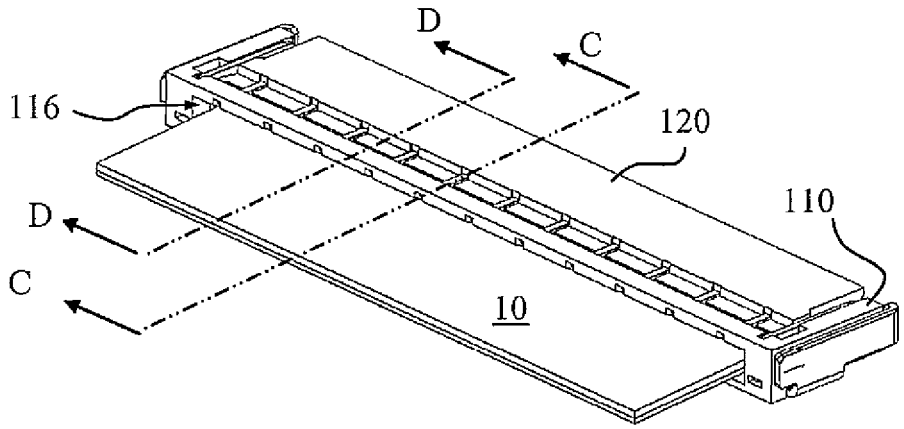

FIG. 8

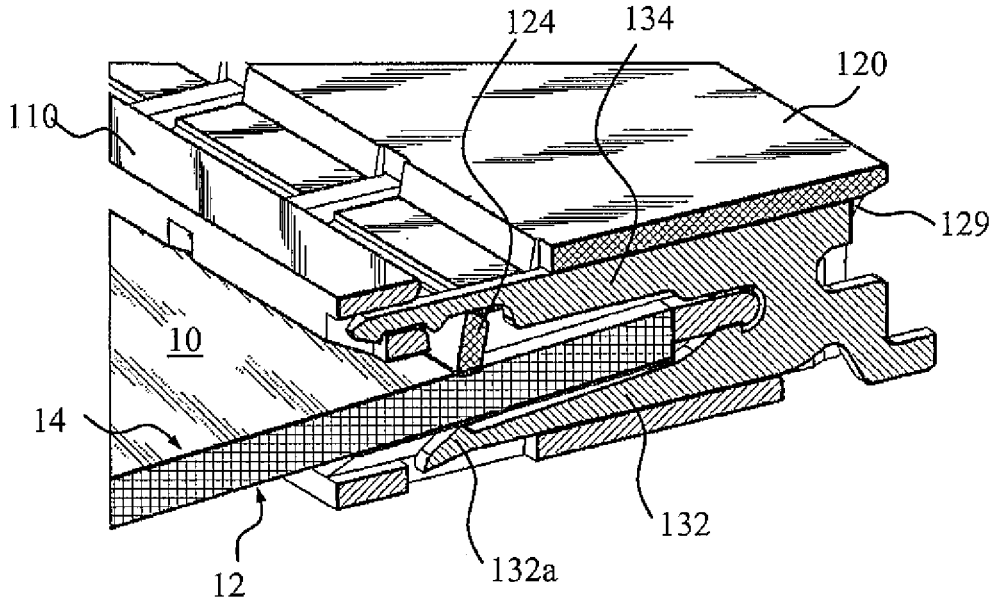

FIG. 9

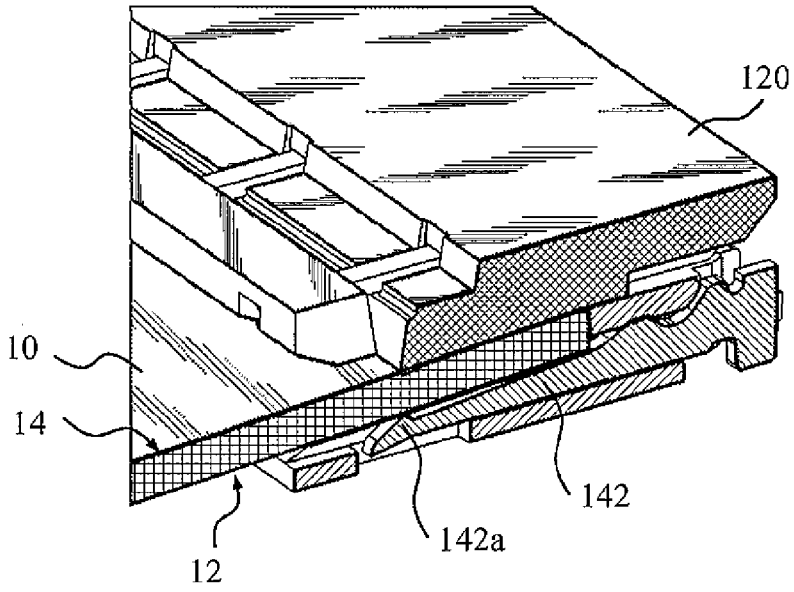

FIG. 10

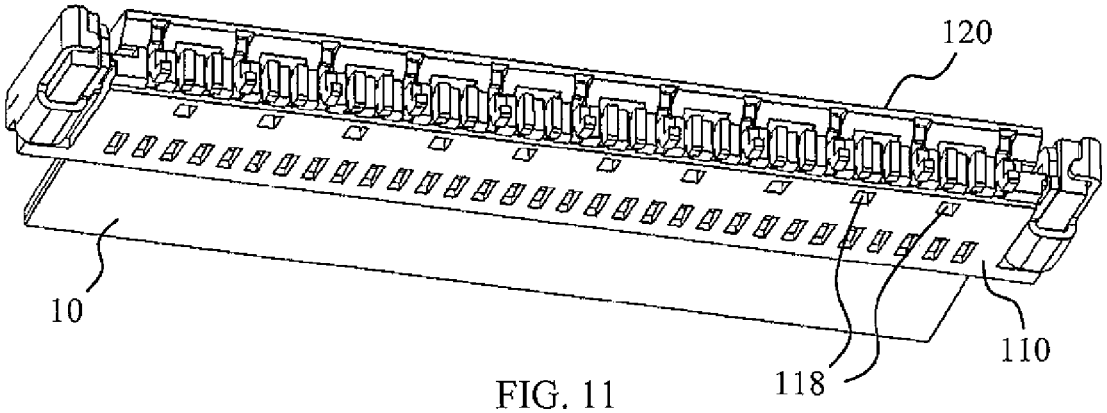

FIG. 11

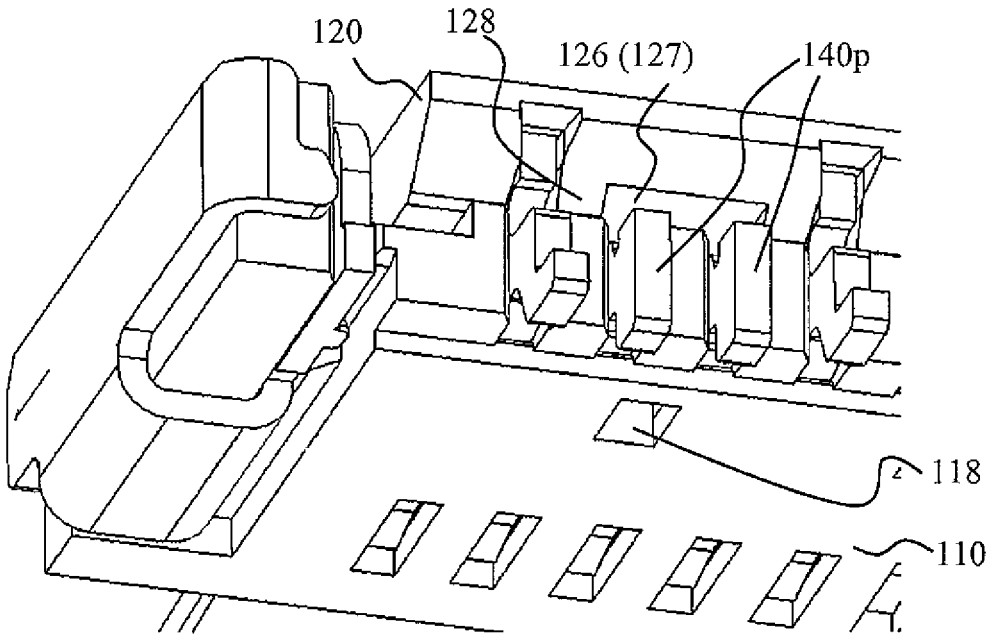

FIG. 12

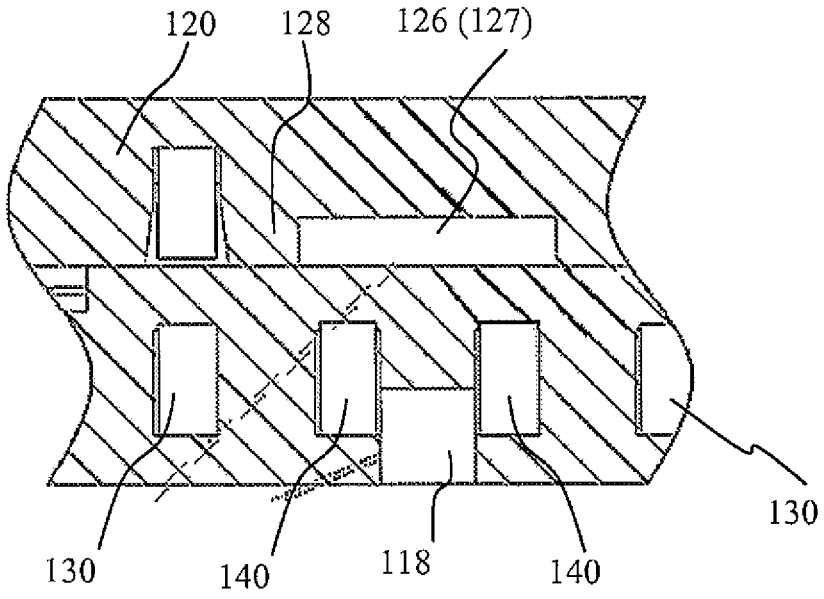

FIG. 13

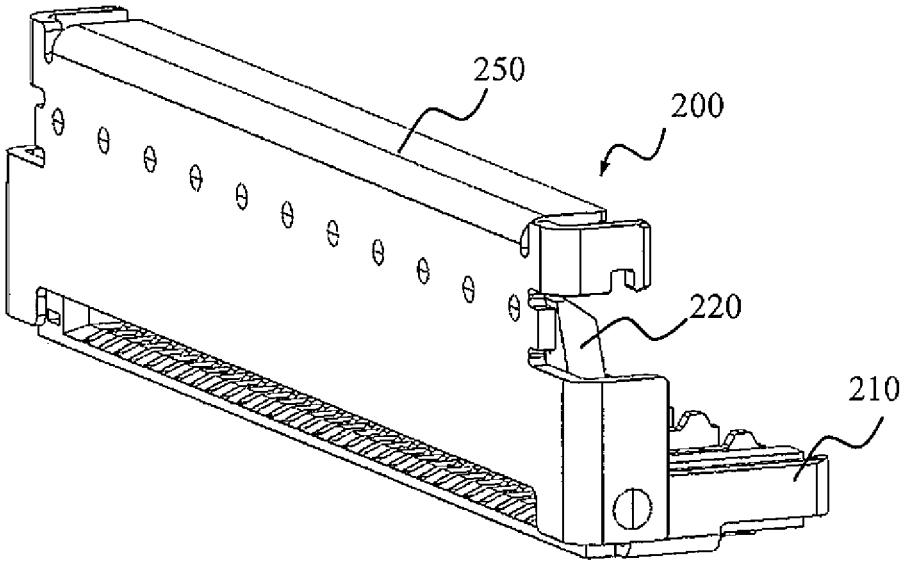

FIG. 14

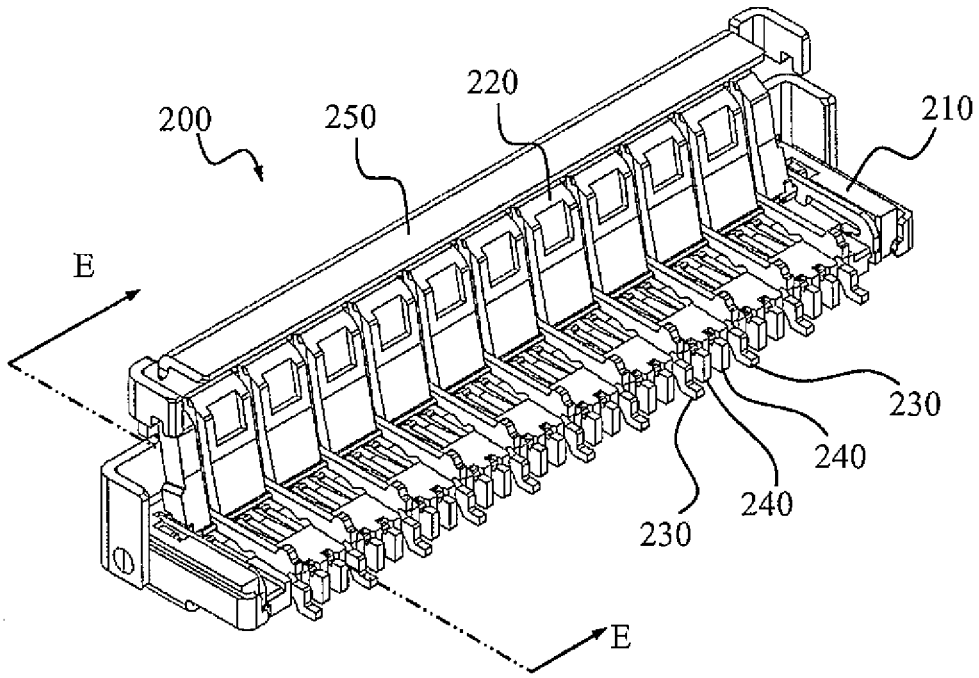

FIG. 15

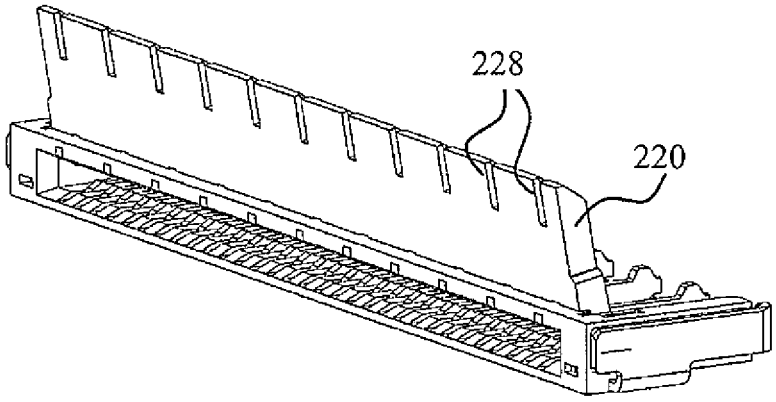

FIG. 16

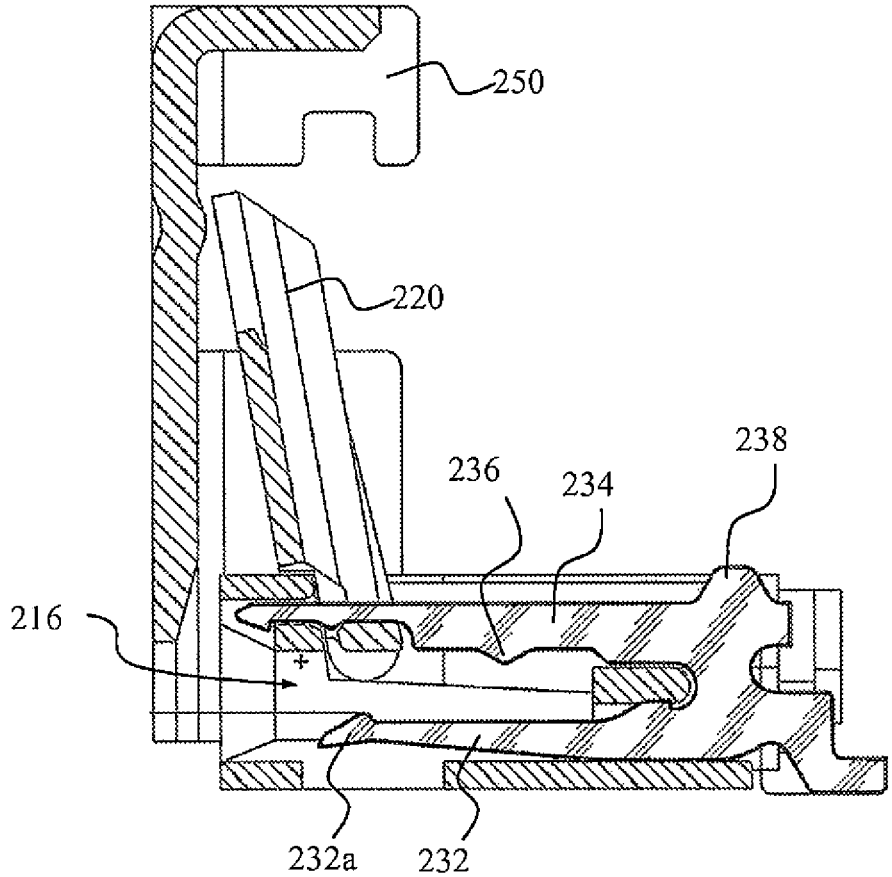

FIG. 17

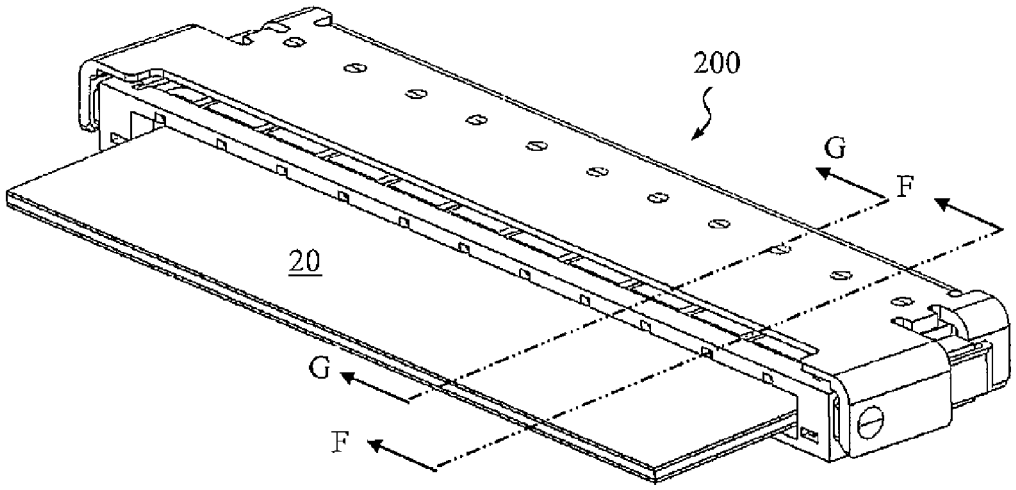

FIG. 18

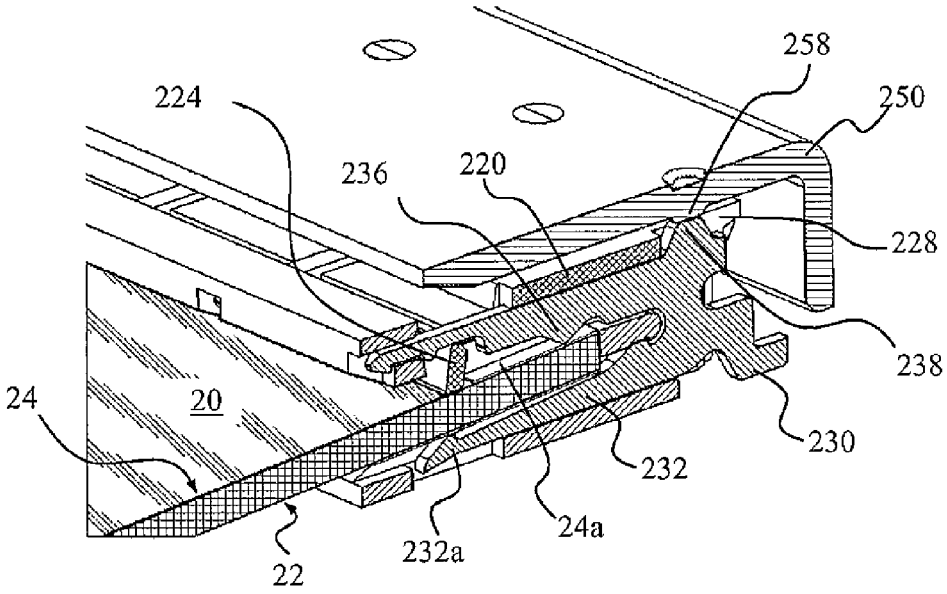

FIG. 19

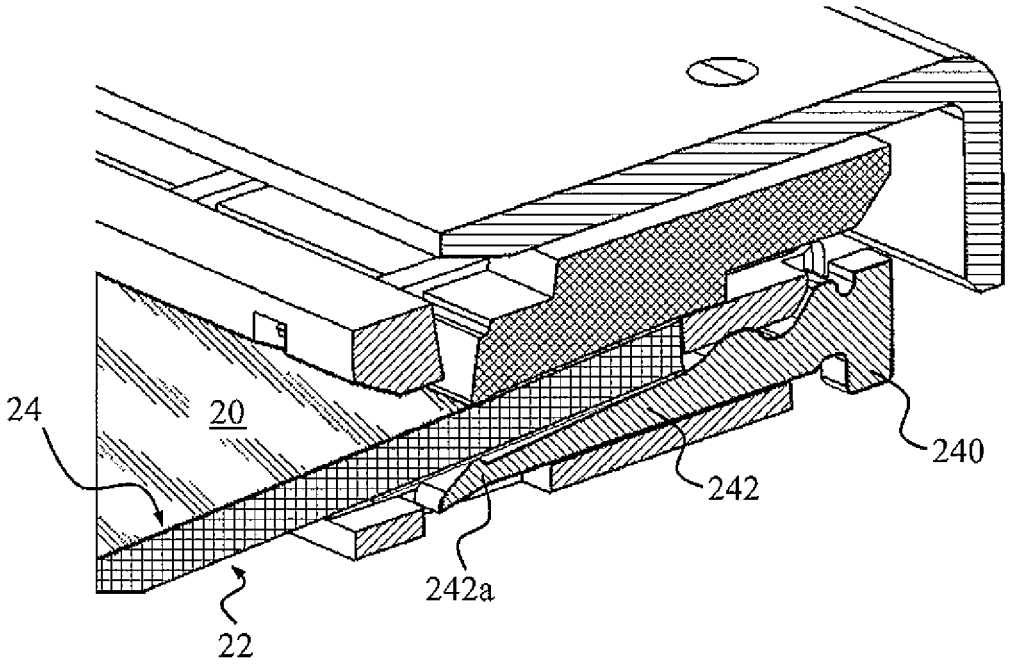

FIG. 20

HIGH SPEED FLEXIBLE PRINTED CIRCUIT CONNECTOR

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation patent application of U.S. Patent Application Ser. No. 13/880,836 filed Jun. 10, 2013, which is a national stage application of PCT Application No. PCT/IB2011/002853 filed Oct. 14, 2011, which claims priority on Application No. PCT/IB2010/003029 filed Oct. 22, 2010, which are all hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to an electrical connector, and more particularly to an electrical connector for connecting to a flexible printed circuit board.

BACKGROUND OF THE INVENTION

Flexible printed circuit (FPC) connectors are widely used in many electronic devices and systems for transmitting electrical signals. Conventional FPC connectors suffer signal integrity degradation and therefore are difficult to transmit signal in high speed. The present invention provides FPC connectors which are capable of transmitting signals in high speed and with improved signal integrity.

SUMMARY OF THE INVENTION

According to one aspect, embodiments of the present invention provides a high speed flexible printed circuit (FPC) connector which includes a housing with ground and signal terminals arranged in the housing along a lateral direction. The housing has a cavity for receiving an FPC board therein. Each ground terminal has a first branch arm positioned adjacent to a bottom wall of the cavity and a second branch arm positioned adjacent to a top wall of the cavity. Each signal terminal is of a single, non-branched elongated shape and the signal terminals are positioned adjacent to the bottom wall of the cavity. Every two of the signal terminals are positioned adjacent to each other to form a signal terminal pair for differential signal transmission. Each signal pair is sandwiched between the first branch aims of two ground terminals. Signal terminals without branch can provide the connector with better signal integrity. An actuator is coupled to the housing for fixing the FPC board in the cavity to establish electrical connections. The actuator may have recesses corresponding to the positions of the signal pairs to provide a dielectric constant different from that of the other parts of the actuator.

For a better understanding of the present invention and its purpose and preferred embodiments, further description accompanied by figures is provided in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective front view of an FPC connector according to one embodiment of the present invention and to be connected to an FPC board;

FIG. **2** is a perspective rear view of the connector shown in FIG. **1**

FIG. **3** is an exploded view of FIG. **2**;

FIG. **4** is a perspective view of a first type of contact terminal of the connector shown in FIG. **1**;

FIG. **5** is a perspective view of a second type of contact terminal of the connector shown in FIG. **1**;

FIG. **6** is a cross-sectional view of FIG. **2** along A-A;

FIG. **7** is a cross-sectional view of FIG. **2** along B-B;

FIG. **8** is a perspective view of FIG. **1** when the FPC board is connected to the connector;

FIG. **9** is a cross-sectional view of FIG. **8** along C-C;

FIG. **10** is a cross-sectional view of FIG. **8** along D-D;

FIG. **11** is a perspective bottom view of FIG. **8**;

FIG. **12** is a partial enlarged view of FIG. **11**;

FIG. **13** is a partial cross sectional view of FIG. **12**;

FIG. **14** is a perspective front view of an FPC connector according to another embodiment of the present invention;

FIG. **15** is a perspective rear view of FIG. **14**;

FIG. **16** is a perspective front view of FIG. **14** with the metal cover omitted;

FIG. **17** is a cross-sectional view of FIG. **17** along E-E;

FIG. **18** is a perspective view of FIG. **14** when an FPC board is connected to the connector;

FIG. **19** is a cross-sectional view of FIG. **18** along F-F;

FIG. **20** is a cross-sectional view of FIG. **18** along G-G.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in FIGS. **1**, **2** and **3**, an FPC connector **100** according to one embodiment of the present invention includes a housing **110** and an actuator **120** pivotally attached to housing **110**. A plurality of first and second sets of terminals **130** and **140** are arranged in housing **110**. Housing **110** has a cavity **116** accessible from front end **102** of connector **100**. Cavity **116** is to allow insertion of an end portion of an FPC board **10** therein, by which an electrical connection can be established between FPC board **10** and connector **100**. An actuator **120** is coupled to housing **110** and supported by a pair of brackets **150** which are mounted to housing **110**.

As shown in FIG. **4**, each of the first set of terminals **130** has a first branch arm **132** at lower side and second branch arm **134** at upper side. First and second branch arms **132** and **134** are connected integrally to a base portion **136**. With reference to the orientation shown in FIG. **4**, at distal end of first branch arm **132** there is formed a first contact projection **132***a*. First branch arm **132** extends backwardly beyond base portion **136**, and forms a first tail portion **138** at the proximal end of first branch arm **132**.

As shown in FIG. **5**, each of the second set of terminals **140** is of a generally elongated shape having a contact arm **142**. At distal end of contact arm **142** there is formed a second contact projection **142***a*. At proximal end of contact arm **142** there is formed a second tail portion **148**.

As shown in FIG. **6**, first set of terminals **130** (only one is shown) are fixed to housing **110**. First branch arm **132** of each of first set of terminals **130** is inserted into housing **110** through a first fixing slot **112***a*. A front tip **137** of second branch arm **134** of each of first set of terminals **130** is inserted into a second fixing slot **114** of housing **110**. Actuator **120** is coupled to housing **110** with pivot **122** held to housing **110** by holding portion **135** formed on second branch arm **134** between tip **137** and base portion **136** of first contact terminals **130**. With the holding action provided by second branches **134** of first set of terminals **130**, actuator **120** is prevented from being detached from housing **110**, but is allowed to rotate relative to housing **110** about pivot **122**. After first set of terminals **130** are assembled to housing **110**,

first branch arms **132** are positioned at a bottom side **116***a* of cavity **116**, and second branch arms **134** are positioned at a top side **116***b* of cavity **116**.

As shown in FIG. **7**, second set of terminals **140** (only one is shown) are fixed to housing **110**, with contact arm **142** inserted through a third fixing slot **112***b*. After being assembled to housing **110**, second set of terminals **140** are positioned at a bottom side **116***a* of cavity **116**. As such, at bottom side **116***a* of cavity **116**, there are arranged both the first branch arms **132** of first set of terminals **130** and the second set of terminals **140**. At top side **116***b*, there are arranged only the second branch arms **134** of first set of terminals **130**. Another words, between two adjacent ones of the first branch arms **132**, there are disposed two contact arms **142** of second set of terminals **140**, but between two adjacent ones of the second branch arms **142**, there is no any part of second set of terminals **140** being disposed therein. Instead, there is formed a space between two adjacent ones of the second branch arms **142**.

First branch arm **132** and contact arm **142** are now fixed to housing **110** in a cantilevered manner, hence first contact projection **132***a* and second contact projection **142***a* extend into, and become resiliently deflectable within, cavity **116** of housing **110**.

The first set of terminals **130** are configured as ground terminals **130** for connector **100**, denoted in FIG. **2** as "GND (ground)" terminals. Every two of the second terminals **140** are positioned next to each other to form a signal contact pair **140***p*, denoted in FIG. **2** as "S+" and "S−" terminals for connector **100**, for transmission of a pair of differential signals. The ground terminals **130** and signal contact pairs **140***p* are arranged in housing **110** in a staggered manner, i.e. each signal contact pair **140***p* is sandwiched between two adjacent first branch arms **132** of ground terminals, as shown in FIG. **2**.

As shown in FIGS. **8**, **9** and **10**, when in use, the front end of an FPC board **10** is inserted into cavity **116** of housing **110**, and actuator **120** is rotated from a release position (FIGS. **6** and **7**) to a lock position (FIGS. **8**, **9** and **10**). At the lock position, a cam **124** formed on actuator **120** presses against top surface **14** of FPC board **10**, which causes bottom surface **12** of FPC board **10** to contact with contact projection **132***a* of first branch arm **132** of each of the first set of terminals **130**, as well as contact projection **142***a* of contact arm **142** of each of the second set of terminals **140**. Electrical connections can therefore be established between FPC board **10** and terminals **130** and **140**. Since second set of terminals **140** which serve as the signal contact terminals do not have any upper arm, as is the case of the first contact terminals **130**, the negative effects to signal integrity caused by conventional contact terminals having such upper arm, can be eliminated or at least substantially reduced. Only the first set of terminals **130**, which serve as ground contact terminals, have the upper arms which hold the actuator **120** to housing **110** and support the operation of actuator **120**. In this way, actuator **120** is allowed to rotate and can be prevented from being detached from housing **110**.

Actuator **120** maybe formed with recesses **126** on its main plate **121**, as shown in FIGS. **2**, **11**, **12** and **13**. Recesses **126** are located such that when actuator **120** is at the lock position, each recess **126** overlaps one signal contact pair **140***p* of second set of terminals **140**, providing an air gap **127** above each signal pair **140***p*. Air gaps may be used to provide a dielectric constant (i.e. dielectric constant of air) different from that of the adjacent parts **128** (i.e. dielectric constant of the actuator material of e.g. plastic) of actuator **120**, to further improve the signal integrity, and to increase the signal transmission speed.

Additionally, actuator **120** maybe formed with grooves **129** on main plate **121**, as shown in FIGS. **2**, **3** and **9**. Each groove **129** is located between two adjacent recesses **126** and corresponding to the locations of second branch arm **134** of first set of terminals **130**. When actuator is at the lock position, as shown in FIG. **9**, each of the second branch arms **134** of first set of terminals **130** is partially received into a corresponding groove **129**. One would appreciate that grooves **129** can be useful to reduce the thickness of actuator and hence to reduce the overall thickness of connector **100**.

Further, between two of the second contact terminals **140**, there may be formed air spaces in the form of voids **118** in housing **110**. The shape and dimension of voids **118** may vary, providing dielectric constant of air different from other part of housing **110** which are made of housing material, e.g. plastic. Voids **118** are therefore useful to further adjust the signal properties to match the signal transmission requirements.

According to another embodiment of the present invention, as shown in FIGS. **14**, **15** and **16**, a connector **200** has a housing **210** and an actuator **220** pivotally attached to housing **210**. A plurality of first and second sets of terminals **230** and **240** are arranged in housing **210**, in a manner the same as that of the previous embodiment. Second set of terminals **240**, which serve as signal contacts, have the same structure as that of the previous embodiment. However, first set of terminals **230** are structured differently, as illustrated below in further details.

Connector **200** further includes a metal cover **250** coupled to housing **210**, to provide a shielding effect as well as an additional grounding effect to connector **200**. Metal cover **250** is rotatable relative to housing **210** between an open position (FIG. **17**) to allow actuator **220** to move to the release position, and a close position (FIG. **19**) to enclose actuator **220** when the actuator **220** is at the lock position.

As shown in FIG. **17**, each of the first set of terminal **230** has a first branch arm **232** at lower side, with a contact projection **232***a* at frond end (left side of FIG. **17**) thereof, for contacting to an FPC board. Second branch arm **234** of first contact terminal **230** at upper side has a first projection **236** and a second projection **238** formed thereon. First projection **236** extends into cavity **216** towards lower arm **232**. Second projection **238** extends in an opposite direction from upper arm **234**.

As shown in FIGS. **18**, **19** and **20**, when in use, an FPC board **20** is inserted with its front end portion into cavity **216** of housing **210**, and actuator **220** is closed so as to fix

FPC board **20** to housing **210**. Cam **224** of actuator **220** now presses against the top surface **24** of FPC board **20** which causes the bottom surface **22** to contact first contact protections **232***a* of first set of terminals **230** as well as second contact projections **242***a* of second set of terminals **240**. Meanwhile, top surface **24** of FPC board **20** is brought into contact with first projection **236** to establish electrical connections between circuits **24***a* (serving as ground-contacts) on top surface **24** of FPC board **20** and first contact terminal **230**.

On actuator **220** there are formed of a plurality of openings **228** (FIG. **16**) corresponding to the positions of second projections **238** such that, when actuator **220** is rotated to the lock position, as shown in FIG. **19**, second projections **238** pass though openings **228** and are accessible from top side of actuator **220**.

At positions corresponding to second projections **238**, there may be formed a plurality of bosses **258** on metal cover

250. When metal cover **250** is rotated to close position to complete the FPC board connection to connector **200**, each boss **258** is brought into contact with a respective second projection **238** of first set of terminals **230**. A grounding path is therefore established between ground circuit **24***a* of FPC board **24** and metal cover, by the contact between ground circuit **24***a* and first projection **236**, and the contact between second projection **238** and boss **258** of metal cover **250**. Grounding effect is further improved in this regard.

The invention claimed is:

1. An electrical connector comprising: a housing having a cavity for receiving a circuit board therein; an actuator coupled to the housing and rotatable relative to the housing between a release position to allow the circuit board to be inserted into the cavity and a lock position to fix the circuit board in the cavity; signal terminals and ground terminals arranged in the housing, wherein each ground terminal includes a base portion, a first branch arm and a second branch arm both connected to the base portion, the first branch arms being positioned at a bottom side of the cavity and the second branch arms being positioned at a top side of the cavity; wherein the signal terminals are positioned at the bottom side of the cavity; wherein the actuator comprises a main plate having a plurality of grooves, wherein each groove of the plurality of grooves is adapted to at least partially receive the second branch arm of a corresponding ground terminal; and wherein every two of the signal terminals are positioned adjacent to each other and sandwiched between the first branch arms of two ground terminals.

2. The electrical connector of claim **1**, wherein the housing further comprising voids each being located between two adjacent signal terminals.

3. The electrical connector of claim **1**, wherein the main plate comprises a plurality of recesses formed at positions corresponding to the signal terminals, such that when the actuator is at the close position, each recess overlaps with two adjacent signal terminals.

4. The electrical connector of claim **3**, wherein the plurality of grooves are located between two adjacent recesses for accommodating the second branch arm of the ground terminal.

5. The electrical connector of claim **1**, further comprising a metal cover coupled to the housing, wherein the metal cover is rotatable relative to the housing between an open position to allow the actuator to move to the release position, and a close position to enclose the actuator when the actuator is at the lock position.

6. The electrical connector of claim **5**, wherein the main plate comprises at least one opening formed thereon, wherein at least one of the ground terminals includes a projection extending through the at least one opening when the actuator is at the lock position.

7. The electrical connector of claim **6**, wherein when at the close position, the metal cover is in contact with the at least one projection.

8. The electrical connector of claim **1**, wherein the second branch arms each includes a tip inserted into the housing and a holding portion between the base portion and the tip, wherein the actuator includes a pivot disposed between the holding portion and the housing such that detachment of the actuator from the housing is prevented.

9. An electrical connector comprising: a housing having a cavity for receiving a circuit board therein; an actuator coupled to the housing and rotatable relative to the housing between a release position to allow the circuit board to be inserted into the cavity and a lock position to fix the circuit board in the cavity; signal terminals and ground terminals arranged in the housing, wherein each ground terminal includes a base portion, a first branch arm and a second branch arm both connected to the base portion, the first branch arms being positioned at a bottom side of the cavity and the second branch arms being positioned at a top side of the cavity; wherein the actuator comprises a main plate having a plurality of grooves, wherein each groove of the plurality of grooves is adapted to at least partially receive the second branch arm of a corresponding ground terminal; and wherein every two of the signal terminals are positioned adjacent to each other and sandwiched between the first branch arms of two ground terminals.

10. The electrical connector of claim **9**, wherein the housing further comprising voids each being located between two adjacent signal terminals.

11. The electrical connector of claim **9**, wherein the main plate comprises a plurality of recesses formed at positions corresponding to the signal terminals, such that when the actuator is at the close position, each recess overlaps with two adjacent signal terminals.

12. The electrical connector of claim **11**, wherein the plurality of grooves are located between two adjacent recesses for accommodating the second branch arm of the ground terminal.

13. The electrical connector of claim **9**, further comprising a metal cover coupled to the housing, wherein the metal cover is rotatable relative to the housing between an open position to allow the actuator to move to the release position, and a close position to cover the actuator when the actuator is at the lock position.

14. The electrical connector of claim **13**, wherein the main plate comprises at least one opening formed thereon, wherein at least one of the ground terminals includes a projection extending through the at least one opening when the actuator is at the lock position.

15. The electrical connector of claim **14**, wherein when at the close position, the metal cover is in contact with the at least one projection.

16. The electrical connector of claim **9**, wherein the second branch arms each includes a tip inserted into the housing and a holding portion between the base portion and the tip, wherein the actuator includes a pivot disposed between the holding portion and the housing such that detachment of the actuator from the housing is prevented.

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